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Constructs for Collaboration:
Concepts from the Science of Teams to Address the Challenges of Team Science

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Overview

- Part One
  - *Interdisciplinarity as teamwork*
- Part Two
  - *Tasks, Training and Technology for team science*

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Interdisciplinarity as Teamwork

- Interdisciplinarity is not just a scientific activity, **it is a team activity**
- It is a process engaged by members of a **coordinated scientific team**
- Teamwork has long occurred **outside of science**
  - ***Two or more people who interact dynamically, interdependently and adaptively toward a shared goal (Salas et al., 1992).***
  - Teams brought together to achieve some end an individual could not achieve alone
  - Do so while maintaining only partially overlapping knowledge
  - So it is with interdisciplinary research – *team science*
  - **Suggest we reframe *interdisciplinarity* as a process of teamwork to be mastered**

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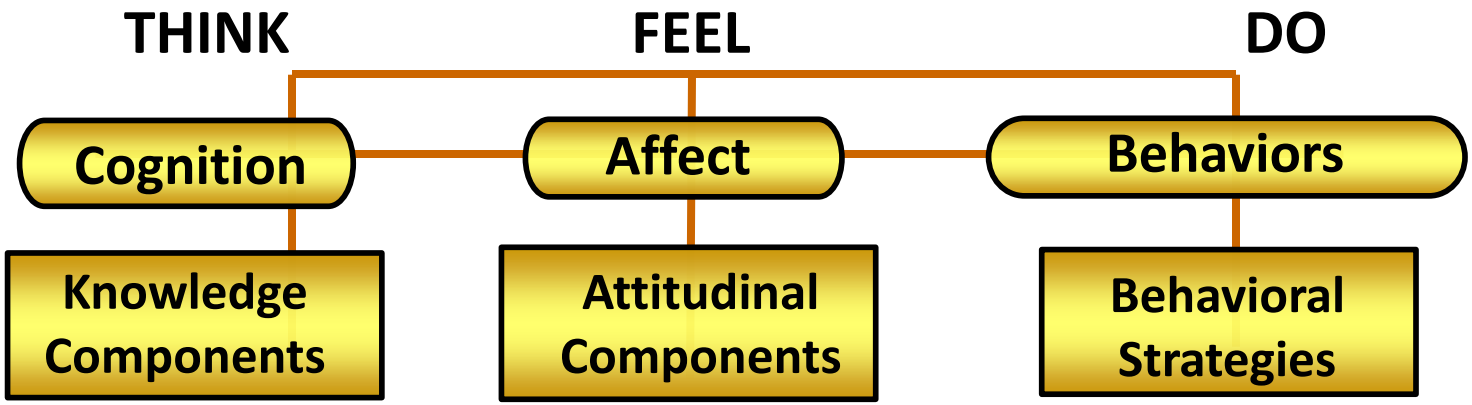
Interdisciplinarity as Teamwork



- Mental Models
- Transactive Memory
- Metacognition
- Problem Solving

- Cohesion
- Collective Efficacy
- Collective Orientation
- Psychological Safety

- Supporting/Backup Behavior
- Information Exchange
- Closed Loop Communication
- Leadership
- Mutual Performance Monitoring

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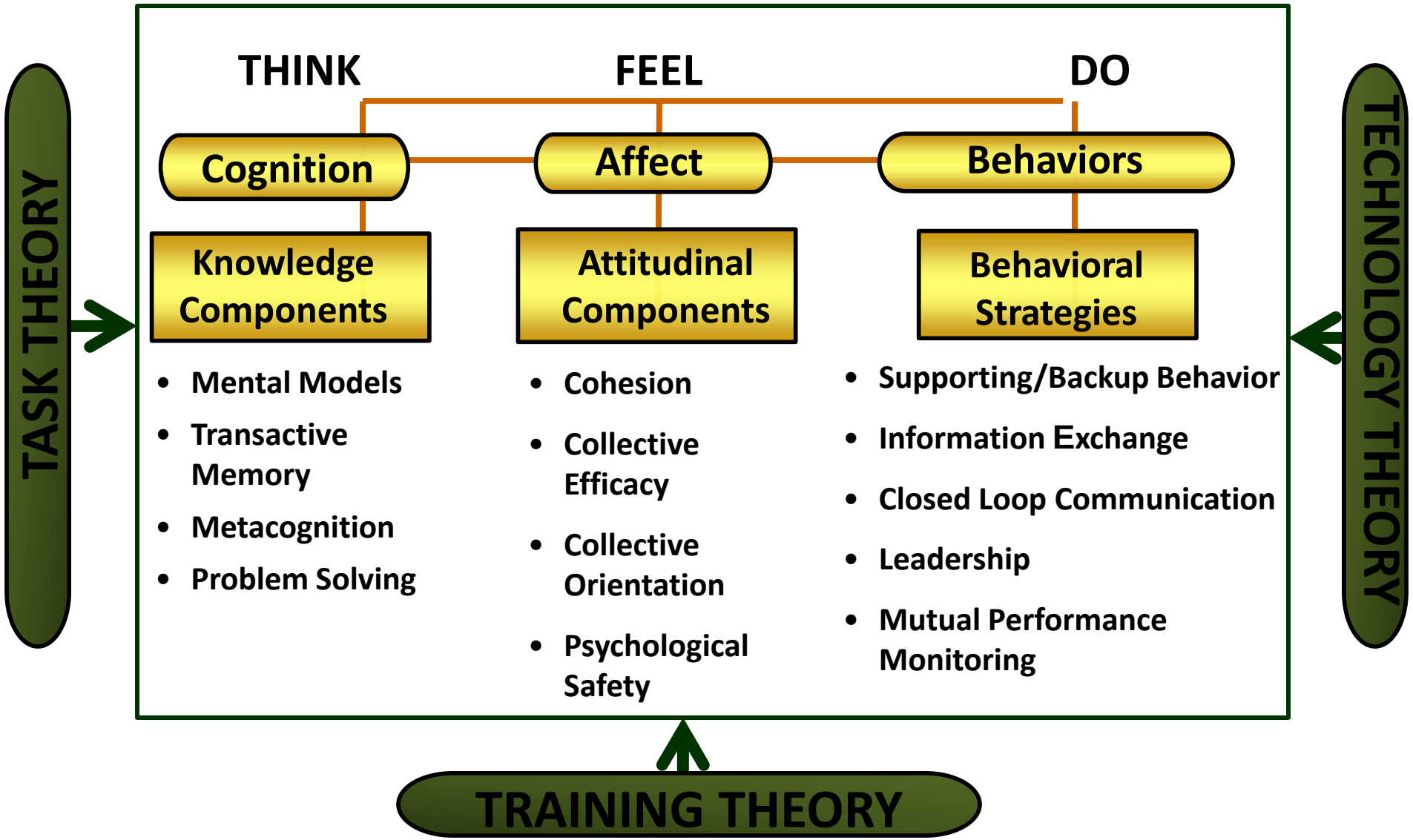
Interdisciplinarity as Teamwork



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Task Theory for STS

Task Variations and Team Science

- **Research Issue**
  - Team Science encompasses a tremendous variety of scientific problems
- **Policy Goal**
  - Understand how variations of theoretically articulated task factors are related to team science outcomes
- **Rationale**
  - *Theoretical Significance*
    - Understanding task influence would expand knowledge of how differing forms of scientific problems alter interactions and outcomes
  - *Practical Significance*
    - Research across variety of contextually-grounded task factors could drive interventions to improve science team performance

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Task Theory for STS

Task Variations and Team Science

- Theoretical Issue – Task Complexity (Wood, 1986)
- Number of problem components and their integration
  - Component Complexity
    - Amount of distinct acts associated with task and amount of problem elements to be processed
  - Coordinative Complexity
    - Degree to which elements need to be integrated for successful task completion

Task Complexity		**Component Complexity**	
		Low	**High**
Coordinative Complexity	**Low**		
	High		

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Task Theory for STS

Task Variations and Team Science

- Theoretical Issue – Task Structure (Campbell, 1991; Simon, 1973)
- Determined by the number of task paths to follow and/or the amount of ambiguity or uncertainty associated with the paths.
  - Multiple Paths
    - Degree to which distinct procedures and/or outcomes are possible in task environment (e.g., numerous research plans)
  - Degrees of Uncertainty
    - Degree to which problem elements are:
      - Relatively unknown or ambiguous
      - Vary in probability of success

Task Structure		Potential Paths	
		Low	High
Degree of Uncertainty	Low		
	High		

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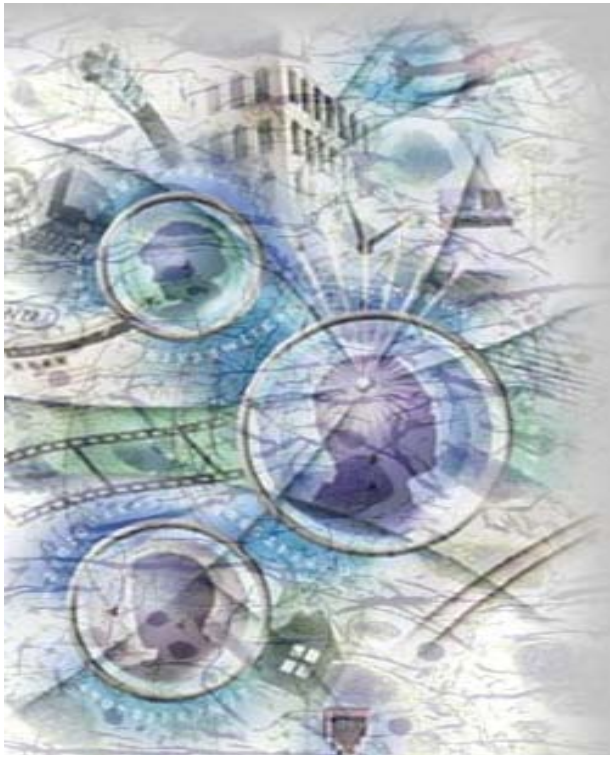
Training Theory for STS

Team and Task Competencies and Team Science

- **Research Issue**
  - The interdisciplinary nature of science teams necessitates a better understanding of the competencies required for effective teamwork
- **Policy Goal**
  - Explicate varied team science competencies so as to develop more refined methods for training
- **Rationale**
  - *Theoretical Significance*
    - Developing a framework of team and task competencies for science teams could inform understanding of their relation to interactions and outcomes
  - *Practical Significance*
    - Articulating the team and task competencies for sciences teams could inform training and pedagogy to better prepare the next generation of team scientists



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Training Theory for STS

Team and Task Competencies and Team Science

Theoretical Issue – Team and Task Competencies

- Way to classify team/task competencies as knowledge, skills, and attitudes necessary in nearly all team situations versus specific to certain teams (Cannon-Bowers, Tannenbaum, Salas, & Volpe, 1995).

Team Competencies

- TEAM GENERIC competencies are those necessary regardless of the task context or the organizational setting, (e.g., communication skills).
- TEAM SPECIFIC competencies are more directly related to individual teams and include knowledge of roles within the team and the abilities held by team members (e.g., team role model)

Task Competencies

- TASK GENERIC competencies are those necessary across task situations (e.g., task planning),
- TASK SPECIFC competencies include understanding objectives or using appropriate procedures (e.g., procedures/methods)

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Team and Task Competencies and Team Science

Theoretical Issue – Team and Task Competencies (Cannon-Bowers, Tannenbaum, Salas, & Volpe, 1995).

		Relation to Task	
		Specific	**Generic**
Relation to Team	**Specific**	***CONTEXT DRIVEN*** • **Knowledge –** ***Team objectives and resources*** • **Skills –** ***Goal analysis*** • **Attitudes -** ***Collective efficacy***	***TEAM CONTINGENT*** • **Knowledge –** ***Teammate characteristics*** • **Skills –** ***Conflict resolution*** • **Attitudes –** ***Team cohesion***
	Generic	***TASK CONTINGENT*** • **Knowledge –** ***Procedures for task accomplishment*** • **Skills –** ***Problem analysis*** • **Attitudes –** ***Trust in competence***	***TRANSPORTABLE*** • **Knowledge –** ***Understanding group dynamics*** • **Skills –** ***Assertiveness*** • **Attitudes –** ***Collective orientation***

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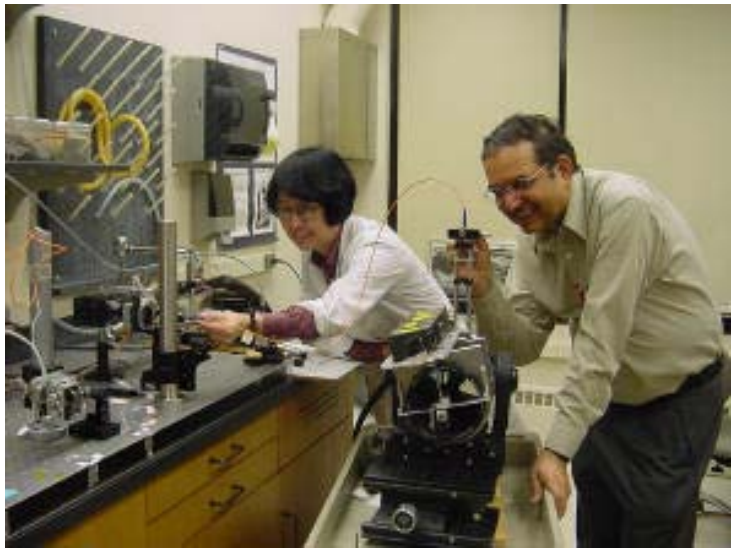
Technology Theory for STS

Technologies for Externalizing Cognition in Team Science

- **Research Issue**
  - Collaborating science teams rely heavily on tools, their environment, and each other to solve problems.
- **Policy Goal**
  - Examine external and distributed problem representations to understand the interplay between team members and their technology in scientific process.
- **Rationale**
  - *Theoretical Significance*
    - Understanding externalized cognition in science teams can help to articulate how cognition emerges from interaction and through a task and context.
  - *Practical Significance*
    - Specifying how externalized cognition is used and adapted can inform the design of new tools to scaffold collaborative cognition in science teams



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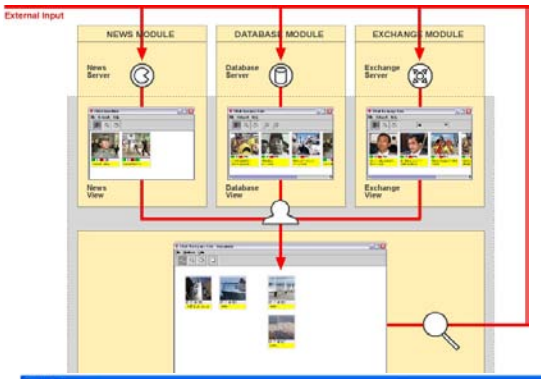
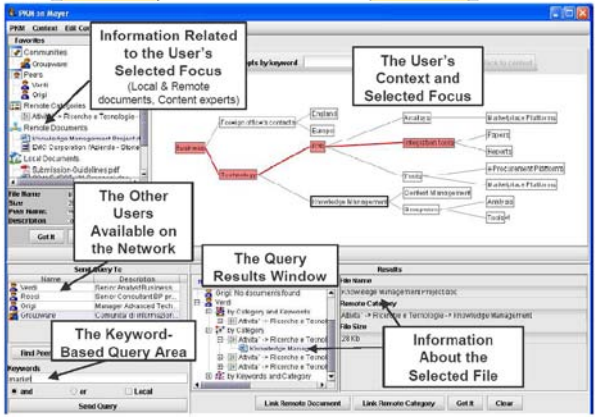
Technology Theory for STS

Technologies for Externalizing Cognition in Team Science

- Theoretical Issue – Technologies to off-load and scaffold collaborative cognition
- Features of the problem often distributed across an internal cognitive system and the environment (Zhang & Norman, 1994; 1995) or between multiple individuals and the environment (Zhang, 1998).



- Externalized Cognition
  - Zhang, 1997
    - "…knowledge and structure in the environment, as physical symbols, objects, or dimensions…" (Zhang, 1997, p. 180).
  - Fiore & Schooler, 2004
    - Allows collaborators to visually articulate abstract concepts
    - Manipulate these task artifacts as problem solving process proceeds
    - Acts as a scaffolding with which the team can construct a shared, and concrete, depiction of the problem



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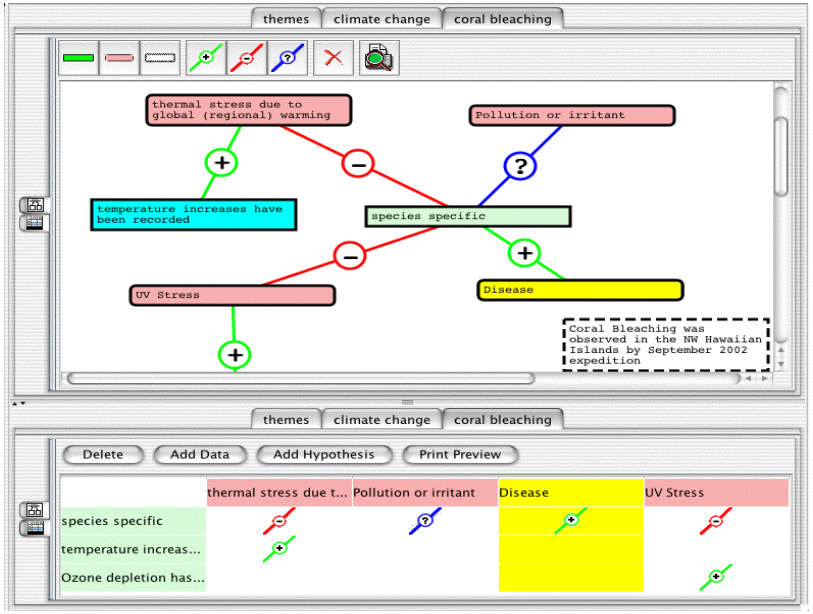
Technology Theory for STS

Technologies for Externalizing Cognition in Team Science

- Medical Team Decision Making (Nemeth and Klock 2004; 2006)
  - Technologies supporting schedules, lists and display boards support DM and planning by mediating collective work
  - Such externalizations help maintain a shared overview of the total activity and are products of various work activities that are distributed in time and location
- Belvedere Software – Simulating Argumentation
  - Supports construction of, and reflection on, diagrammatic representation of ideas
  - Uses evidence maps and concept maps
  - Reifies argument construction



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Conclusions

- Task Variations and Team Science
  - *Theoretically derived methods for classifying influence of task could better prepare science teams for interaction.*
- Team /Task Competencies and Team Science
  - *Identifying a framework of team and task competencies is necessary for the development of targeted training in team science*
- Externalized Cognition and Team Science
  - *Understanding how collaborative problem solving uses tools to create cognitive artifacts will help develop new tools to scaffold cognition.*

Thank You!

Questions or Comments?